THE EFFECTS OF RACE, SES, AND GENDER ON HPV VACCINATION UPTAKE

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The Effects of Race, SES, and Gender on HPV Vaccination Uptake

Human papillomavirus (HPV) is a strand of sexually transmitted infection that has been linked to several varieties of cancer (Centers for Disease Control and Prevention 2015). In the United States, these cancers affect more than 25,000 people annually (Bosch, et al. 2002; Centers for Disease Control and Prevention 2015). In 2006, the Advisory Committee on Immunization Practices recommended a three-dose HPV vaccination for females 11-12 years of age and "catch up" vaccination for those up to 26 years of age (Markowitz, et al. 2007). This recommendation was revised in 2010 to include males ages 9 through 26 (Advisory Committee on Immunization Practices 2010).

The vaccination, most commonly distributed under the trade names of Gardasil and Cervarix, is administered in a three-dose series; however, even a single dose has been shown to be 82% effective against the targeted strains of the virus in females (Markowitz, et al. 2013). Despite this effectiveness, vaccine uptake remains relatively low, with Markowitz and colleagues (2013) finding that only 32% of 13-17 year-old females have received all three doses and with Schmidt and Parsons (2014) finding that only 14% of 18-26 year-old females have received all three doses (using pooled data from 2008-2012).

Vaccination uptake is even lower among males, with the CDC recently estimating that less than 10% of males aged 13-17 have received a single dose (Centers for Disease Control and Prevention 2012). While low uptake in males may be due in part to the recency of the recommendation, the generally low uptake in both sexes seems to stand as a testament that many barriers still exist to the receipt of HPV vaccination.

FUNDAMENTAL CAUSES OF DISEASE

It is quite possible that differences in socioeconomic status and social support are responsible for many of the barriers associated with this relatively low HPV vaccination uptake. The fundamental causes of disease theory, first proposed by Link and Phelan (1995), attempts to explain health disparities as being the result of differences in socioeconomic status and social support. These are described as the "fundamental causes" of disease because they are seen as preceding the health behaviors and outcomes that they are associated with, as well as the risk factors that are also tied to such outcomes. The theory has been supported by the fact that associations between socioeconomic status and health have remained persistent (Phelan, Link, and Tehranifar 2010)

More specifically, the theory of fundamental causes has four main features that are outlined by Phelan, Link, and Tehranifar (2010). First, the theory asserts that multiple disease outcomes are influenced by socioeconomic status and social support. These factors are not simply associated with one disease, but rather with many. Likewise, the second major point of the theory is that these fundamental causes affect disease outcomes through multiple risk factors. Rather than being able to say that a particular change in socioeconomic status results in one specific change in the risk factor for a single disease, we see that a change in socioeconomic status results in a variety of changes in a variety of risk factors.

The third assertion of the theory is that socioeconomic status and social support involve access to resources that can be beneficial in ensuring effective treatment following a diagnosis or in avoiding risk factors altogether. Finally, the theory posits that these disparities in health are consistently associated over time with disparities in socioeconomic status and social support. Thus, the theory of fundamental causes has far reaching implications that are beyond the prognosis associated with only a handful of diseases.

Preventive measures such as HPV vaccination fall squarely into the third assertion made by fundamental causes theory, as it serves to avoid the onset of disease or minimize the risk factors that can lead to diagnosis. As such, HPV vaccination is one of many windows through which we can explore this particular aspect of the theory and attempt to explain health disparities. Through such exploration, we can better understand the social mechanisms associated with preventive measures and health behaviors.

FACTORS ASSOCIATED WITH HPV VACCINATION UPTAKE

A myriad of studies have explored various predictors of female HPV vaccination uptake, including race/ethnicity, health care access, education, and discussion of the vaccination with a family member or physician (Caskey, Lindau, and Alexander 2009; Schmidt and Parsons 2014). However, it remains largely under-explored how significant such factors are for males or whether male-specific barriers exist. This is likely due to the relatively recent introduction of the vaccination for males and thus represents a new area for further study of vaccination trends.

Gender

While little is known about the specifics of male HPV vaccination uptake, prior literature suggests that females are much more likely than men to take a proactive role in their healthcare, especially regarding sexual health. This is possibly due to existing stereotypical gender roles in society in which females are expected to take the initiative (Emmers-Sommer, et al. 2009). Such stereotypical gender roles are evident not only through differences in help-seeking behavior related to sexual health, but also through patient-provider interactions. Emmers-Sommer and colleagues (2009) found that doctors were much more likely to discuss matters of sexual health with females than they were with males, indicating that such norms may be embedded culturally in the medical system.

Keeping such strong gender norms in mind, it seems likely that the factors affecting vaccination uptake for females may be less influential in males. Additionally, the factors affecting vaccination uptake for males may be different from those affecting uptake in females. However, much of this is speculation as little research to date has focused directly on gender differences in HPV vaccination uptake, making this an interesting and necessary area for exploration.

Race/Ethnicity

Prior literature has uncovered a number of racial/ethnic disparities regarding HPV vaccination uptake among females, with black, Asian, and Hispanic females all being less likely to vaccinate when compared to their white counterparts (Keenan Hipwell, and Stepp 2012; Lee, et al. 2015; Lefkowitz, et al. 2014; Reimer, et al. 2014). However, there is still much speculation as to the mechanisms that create these disparities, indicating a need for further research. Potential mechanisms behind these disparities include deficiencies in health-related information, existing cultural beliefs, and the language barrier experienced when interacting with healthcare providers. Not all of these apply equally to each race, however, and no single factor should be taken as the sole cause of vaccination uptake differences.

Black, Asian, and Hispanic females have all been shown to possess less information about HPV and its vaccination than their white peers (Chau, et al. 2014; Fernandez, et al. 2009; Gelman, et al. 2011; Gerend and Magloire 2008; Hughes, et al. 2009; Kepka, et al. 2015;

Molokwu, Fernadez, and Martin 2014; Lee, et al. 2015). However, black and Hispanic females have exhibited a willingness to learn more about the disease (Gerend and Magloire 2008; Chau, et al. 2014). This implies that lower vaccination uptake among these groups may be the result of lack of resources and information or insufficient interaction with the healthcare system rather than a choice based on their prevalent racial/ethnic cultures regarding medicine.

Asian females and males alike have been shown to exhibit less adherence to conventional Western medicine than their peers in other racial groups and instead prefer traditional or non-Western treatments (Ngo-Metzger 2003). This is often a deterrent to effective interaction with the healthcare system, as Asian patients have reported that they feel that their beliefs are not respected and that healthcare providers should be less judgmental in their interactions regarding these beliefs (Ngo-Metzger 2003). Such interactions may lead to further distrust of the healthcare system and even less willingness to utilize Western preventive medicine.

Recent Hispanic and Asian immigrants may also have lower HPV vaccination uptake due to the language barrier experienced in their interactions with healthcare providers. Prior literature has shown that these groups often experience difficulties in communicating with physicians and largely passive interactions. This lack of effective communication has been identified as hindering knowledge development pertaining to health issues (Getrich, et al. 2014; Ngo-Metzger 2003). Such difficulties may lead to less utilization of preventive measures such as vaccination against HPV, as individuals are less able to understand the benefits of such measures.

Language barrier problems and deficiencies serve as a means of understanding HPV vaccination uptake from the fundamental causes perspective – individuals of certain races/ethnicities experience a difference in their health resources and therefore are less likely to vaccinate. Therefore, race is one of the ways in which we can, at least peripherally, gauge the effect of the fundamental causes of disease when it comes to matters of preventive health.

While the present study does not account directly for immigrant status or English language proficiency, it does account for variables that may be associated with acculturation into Western society and its medical system. Namely, it includes level of education and an assortment of variables related to interaction with the healthcare system. These may not be direct measures of an individual's acculturation and language abilities; however, they are likely to provide a decent indication of these factors.

Income

There appears to be a lack of consensus in empirical research regarding the relationship between income and HPV vaccination uptake. While studies have found that being below the federal poverty threshold is not significantly associated with vaccination uptake (Schmidt and Parsons 2014) and that those receiving free lunches in schools do not differ significantly in their intention to vaccinate their child (Brabin, et al. 2006), other studies have found that household income is significantly associated with vaccinate uptake (Lau, Lin, and Flores 2012; Tiro, et al. 2012).

These discrepancies in findings indicate that there is still room to explore the relationship between income and HPV vaccination uptake. Perhaps analysis of this relationship must be conducted with regards to income or income ranges directly rather than using a proxy such as the federal poverty threshold or school lunch programs in order to yield the most precise results. Such an analysis strategy would allow for direct observation of how income relates to vaccination uptake.

It may also be the case that income simply is not strongly associated with vaccination because it only becomes important following diagnosis. Perhaps health insurance and public assistance programs cover the cost of vaccination, making the individual's income irrelevant to the decision-making process for preventive measures. In contrast, diagnosis with an illness may indicate the need for expensive treatments that may or may not be covered financially, therefore making those types of health behaviors more sensitive to income. Thus, while income may not explicitly represent a lack of health resources due to public assistance programs and health insurance, it can still be used to highlight potential differences in the ways people utilize these resources.

Education

As regards education, existing literature largely indicates that those who have more highly educated parents are more likely to vaccinate against HPV (Lau, Lin, and Flores 2012; Laz, Rahman, and Berenson 2012; Tiro, et al. 2012). This relationship also appears to be true when considering the educational attainment of those 18 and older, with more highly educated individuals being more likely to vaccinate (Tiro, et al. 2012; Schmidt and Parsons 2014). However, as most quantitative studies regarding vaccination have been cross-sectional in nature or lack relevant information, it is difficult to pinpoint whether it is the education of the parent or the education of the child that is primarily associated with vaccination decisions.

Furthermore, education may mediate racial differences in vaccination uptake. While it is known that racial disparities in HPV knowledge exist in the population, college students have been shown to exhibit no racial differences in their knowledge levels concerning HPV (Gerend and Magloire 2008). This suggests that individuals with more education are more likely to have a better understanding of preventive measures, exhibiting the cognitive skills necessary for decisions related to this care and better access to resources for obtaining it.

Access to Healthcare

Programs that provide healthcare to those with low income may help bridge the socioeconomic divide and thus must be considered when explaining disparities related to many aspects of healthcare. For example, one of the few studies that has found a non-significant relationship between education and HPV vaccination focused only on those who were insured (Rosenthal, et al. 2011). This same study also found that a physician's recommendation is a strong predictor of whether or not a woman will receive the vaccination, further enforcing the importance of contact with the healthcare system.

Since there is no single measurement that can assess the degree of contact an individual has with the healthcare system, we must rely on proxy variables in order to gauge this interaction. This can be accomplished in a variety of ways. In one of the most thorough uses of such proxies, Schmidt and Parsons (2014) used a combination of health insurance status, having a usual place of medical care, having delayed or forgone care due to cost, and having other recommended vaccinations as variables to explore HPV vaccination. Each of these proxy variables exhibited statistically significant results, with women who are more involved with the healthcare system generally being more likely to vaccinate against HPV.

Such proxy variables for healthcare access have been much less explored in their regards to males, with few studies going beyond using health insurance and provider recommendation as variables. One study using these proxies has, however, found a significant relationship between them and vaccination uptake (Reiter, Gilkey, and Brewer 2013). As these variables alone only provide a small amount of information regarding healthcare access, there is much room for expanding upon knowledge in this area.

Race-Gender Intersectionality

While few studies have been conducted regarding racial/ethnic differences in HPV vaccination uptake among males, some early studies have found that black males do not differ significantly from their white counterparts (Reiter, et al. 2011; Reiter, Gilkey, and Brewer 2013). Little information exists in empirical research regarding vaccination uptake among Asian and Hispanic males, as the literature remains exceedingly sparse and represents an area requiring further exploration.

Due to the sparse literature on the topic, it is only possible to speculate regarding any racial disparities that exist for males. It is possible that race is a less significant predictor among males than it is among females, namely because of the "double jeopardy" theory that is prevalent in much of health research. This theory suggests that individuals who belong to multiple minority groups experience multiple disadvantages to health.

Given that females have historically been a minority group in a number of regards, one could argue that they are more susceptible to racial differences than their male counterparts. Males, historically a dominant majority group, may have health-related advantages that offset the same racial disparities that affect females. Thus, the intersection of race and gender may put females in an even more disadvantaged position.

It may also be the case that the "double jeopardy" related to race and gender intersectionality may disproportionately affect vaccination uptake among different races. Races that tend to place more emphasis on masculinity and male dominance in their culture may be see stronger racial-gender differences than other groups. As such, we can expect the racial differences in females of these races to be stronger than in their counterparts from other racial backgrounds.

Of course, it could also be the case that the male HPV vaccination has been available for such a short time that racial differences simply have yet to emerge. Given the relative recency of the vaccination, it is possible that there simply has not been enough time and data to uncover such disparities. If these differences do exist, they may become apparent as more information becomes available.

PROPOSED HYPOTHESES

This study aimed to fill the gaps in the existing literature by directly comparing factors related to HPV vaccination uptake between males and females, particularly regarding their intersection with race. Such comparisons have rarely been conducted in existing research, thus providing interesting grounds for quantitative investigation. Additionally, this study aims to verify the findings of prior literature and to approach some of the gaps aforementioned that are affected by a lack of consensus. Specifically, I would like to establish the following formal hypotheses and their associated rationales regarding this study.

Hypothesis 1. HPV vaccination uptake is lower for black, Asian, and Hispanic females when compared to their white counterparts; however, this is not the case for males.

Hypothesis 2. HPV vaccination uptake has a significant positive relationship with income for both males and females.

Hypothesis 3. More highly educated individuals of both sexes are more likely to receive the HPV vaccination when compared to those individuals without a high school education.

Hypothesis 4. Access to healthcare has a significant positive relationship with HPV vaccination uptake for women, but not for men.

METHODS

This study used data from the 2010-2014 waves of the Integrated Health Interview Series (IHIS) provided by the Minnesota Population Center (Minnesota Population Center and State Health Access Data Assistance Center 2015). The IHIS aggregates data from the National Health Interview Survey (NHIS), which is conducted annually by the Centers for Disease Control and Prevention and the United States Census Bureau and focuses on a broad range of health-related topics. These particular years of the data were chosen, as they were the first to include information regarding both male and female vaccination for HPV. Descriptive statistics for each variable of interest are presented in Table 1.

Population of Interest

This study focused on males and females aged 18-26. This age range has been used by a number of previous studies (e.g. Schmidt and Parsons 2014) and allows for the direct study of adults who are largely responsible for their own healthcare decisions. While this population is not the primary target of vaccination efforts, prior literature has shown that they can still benefit from receiving the HPV vaccination (Markowitz, et al. 2007) and that vaccination efforts within this population can be beneficial to herd immunity (Schmidt and Parsons 2014).

Table 1. Descriptive Statistics for Variables of Interest

	Males		*Females*	
	% of Sample	**% Vaccinated**	**% of Sample**	**% Vaccinated**
Vaccinated	5.3	---	32.6	---
2010	17.0	1.2	17.0	21.4
2011	21.0	2.1	20.9	28.6
2012	20.0	4.1	22.4	33.5
2013	21.0	8.5	20.2	37.2
2014	21.1	9.6	19.5	40.8
Age 18	8.3	14.4	6.9	43.8
Age 19	9.2	7.4	9.1	43.9
Age 20	10.2	6.4	9.6	41.2
Age 21	10.4	4.9	10.9	40.1
Age 22	11.4	4.0	11.8	34.4
Age 23	12.6	4.3	12.4	29.2
Age 24	12.2	4.5	12.7	26.7
Age 25	12.8	3.5	12.9	24.8
Age 26	12.9	2.0	13.7	21.5
White	53.5	5.4	52.2	38.6
Black	13.8	5.1	17.9	28.2
Asian	7.6	4.7	6.4	24.8
Hispanic	23.6	5.5	21.9	23.7
Other	1.6	3.8	1.7	36.4
$0 – $34,999	57.4	5.5	61.0	31.9
$35,000 – $49,999	14.0	5.1	13.4	30.1
$50,000 – $74,999	13.0	4.3	12.5	30.8
$75,000 – $99,999	6.7	5.8	5.8	36.1
≥ $100,000	8.8	5.2	7.2	43.4
Less than High School	14.0	4.2	13.1	21.3
High School or GED	28.8	5.0	24.6	26.3
Any College	57.1	5.7	62.3	37.4
Public	10.4	8.4	21.4	28.0
Private	57.3	6.0	50.8	39.8
Mixed	0.4	7.9	0.9	40.2
Uninsured	29.6	2.2	23.3	20.5
Has Usual Place of Care	63.6	6.6	78.0	35.3
Delayed Care Due to Cost	14.3	3.5	15.7	27.8
Vaccinated for Hepatitis B	48.1	8.2	59.0	40.1
	N = 8461		*N = 9902*	

Variables

The dependent variable of interest for this study was HPV vaccination uptake, which is defined as having received at least one dose of the vaccination and coded as an indicator variable (i.e., 0 for no doses received, 1 for one or more doses received). While this does not yield data regarding vaccination completion (three doses), it allows for the fact that some individuals have not had a chance to complete the vaccination series at this point in time. This is particularly important considering the relative recency of the vaccine's approval for use in males. 33% of females in the sample had received at least one dose of the vaccination, compared to only 5% of males.

Year. Survey year was included as a set of indicator variables for each year with 2010 serving as the reference category. The data were fairly evenly dispersed over the five year period, with slightly fewer respondents in 2010 than other years. Vaccination in both males and females appears to have increased over the 2010-2014 time period, with vaccination increasing in males from 1.2% in 2010 to 9.6% by 2014 and in females from 21.4% in 2010 to 40.8% in 2014.

Age. Although the HPV vaccination is recommended for individuals up to the age of 26, it is primarily targeted at children in their early teens. As such, many older males in the sample may have not been in this primary group at the time of the vaccination's introduction. A control for age was added to allow for this fact, with each age from 18 to 26 being represented by an indicator variable. Age 18 served as the reference group. While respondents were fairly evenly distributed across age groups, it is clear that there was a higher percentage of respondents from the older end of the target range. Vaccination appears to decrease as age increases, with 18-year-olds of both sexes having the highest vaccination rate.

Race/Ethnicity. Race was included as a set of indicator variables for non-Hispanic white, black, and Asian, as well as Hispanic and "other." Non-Hispanic white was used as the reference category and also made up the largest group in the sample with just over 50% of respondents in both sexes. Hispanic respondents made up the second largest group, representing over 20% of the sample. Non-Hispanic blacks made up around 15% of the sample while non-Hispanic Asians made up around 7%. Just over 1% of the sample did not fall into any of these categories. Non-Hispanic white and Hispanic males have the highest vaccination rate, with the Asian and "other" categories having the lowest. In females, whites also have the highest vaccination rate, while Asians and Hispanics have the lowest.

Income. Income was recoded into a set of indicator variables representing various ranges of possible incomes. Most individuals (around 60%) in the sample had an income lower than $35,000. Around 14% of the sample had an income between $35,000 and $49,999, while 13% had an income between $50,000 and $74,999. 6% had incomes between $75,000 and $99,999 and around 8% had incomes of $100,000 or more. The middle income groups of $35,000-$49,999 and $50,000-$74,999 appear to have the lowest vaccination rates. Income lower than $35,000 was used as the reference category.

Educational Attainment. Educational attainment was included as a set of indicator variables for having less than a high school education, having a high school diploma or GED, and having any college education. Having less than a high school education served as the reference category and represented about 14% of the sample. High school graduates with no college education or those with a GED represented about 25% of the sample, while individuals with any college education made up about 60% of the sample. Vaccination appears to increase with education, with those having less than a high school education seeing the lowest vaccination rates and those with any college education seeing the highest.

Health Insurance Status. The respondent's health insurance status was included as a set of indicator variables for being uninsured, having coverage through a public insurance plan (such as Medicaid), having private health insurance coverage (such as that received through an employer), or having some mix of public and private insurance. Uninsured was used as the reference category and represented 30% of the male sample and 23% of the female sample. Those on public insurance represented 10% of the male sample and 21% of the female sample, while about 5% of the sample had only private insurance. 1% of less of the sample had a mix of public and private insurance. In both sexes, it appears that having insurance of any type is associated with a higher vaccination rate than having no insurance.

Usual Place of Care. An indicator variable was included for whether or not the individual reported having a usual place for receiving healthcare, with a value of one indicating the affirmative. 64% of the male sample and 78% of the female sample reported having a usual place of care. Not having a usual place of care was used as the reference category. Of the individuals who reported having a usual place of receiving healthcare, 6.6% of males and 35.3% of females had been vaccinated for HPV.

Delay of Care. As another means of gauging the individual's access to healthcare, an indicator variable was included for having delayed care due to cost in the past 12 months, with a value of one indicating the affirmative. Around 15% of the sample reported having been in this situation. Not having delayed care in the past 12 months was used as the reference category. Of the individuals who reported having delayed care due to cost in the past 12 months, 3.5% of males and 27.8% of females had received the HPV vaccination.

Hepatitis B Vaccination. Having received the hepatitis B vaccination was included as an indicator variable, with a value of one indicating that the individual has received the vaccination. This vaccination is similar to the one for HPV in nature (e.g., it is an optional vaccination that pertains to sexual health). Around half of the male sample and 59% of the female sample reported having received this vaccination. Not having received the vaccination was used as the reference category. 8.2% of males and 40.1% of females who received the hepatitis B vaccination had also received at least one dose of the HPV vaccination.

Analytical Approach

Logistic regression models were analyzed in an additive manner and stratified by gender, starting with a base model consisting only of year and age. The second model controlled for race, while the third added education and income into the estimation. The fourth and final model controlled for variables pertaining to access to healthcare. Stratifying the models by gender allowed for the factors associated with vaccination uptake to be considered in separate male and female contexts. This was particularly important given the ways in which each sex differs in their dealings with the healthcare system.

Conducting the analysis in an additive manner allowed the significance of various factors to be fleshed out with finer detail. For example, if adding a new set of variables results in an earlier set losing significance, it may mean that the new set of variables explains at least part of the differences that existed in the previous model. This is a particularly important analysis strategy when investigating an issue as multifaceted as that of race or class.

Analysis was conducted using the R open-source statistical software and its base components (R Core Team 2015), with post-estimation simulations conducted using the logit modeling provided in the Zelig package for R (Imai, King, and Lau 2015). Post-estimation simulations involved predicting the probabilities based on a given set of characteristics using Monte Carlo simulation methods. This allows for a more in-depth exploration of the data beyond that provided by logistic regression alone and allows more insight into how particular subgroups of the population may differ from their peers.

RESULTS

Results for male-only logistic regression models are presented in Table 2. Vaccination uptake appears to have increased over time for males, with the odds increasing by a factor of 1.856 ($p < 0.05$), 3.870 ($p < 0.001$), 8.610 ($p < 0.001$), and 9.680 ($p < 0.001$) for the years 2011, 2012, 2013, and 2014, respectively when compared to 2010 and only controlling for age in Model 1. In Model 4, once all controls have been added, these coefficients only slightly change. Significance levels for each year stayed roughly the same across models.

As expected since many males in the sample were not a part of the primary target age group for vaccination, age was negatively associated with vaccination uptake. In Model 1, the odds decrease by a factor of 0.448 ($p < 0.001$), 0.387 ($p < 0.001$), 0.272 ($p < 0.001$), 0.225 ($p < 0.001$), 0.239 ($p < 0.001$), 0.255 ($p < 0.001$), 0.187 ($p < 0.001$), and 0.106 ($p < 0.001$) for ages 19 through 26 respectively when compared to 18-year-olds. These coefficients decrease slightly once all controls are added to 0.391 ($p < 0.001$), 0.342 ($p < 0.001$), 0.236 ($p < 0.001$), 0.188 ($p < 0.001$), 0.192 ($p < 0.001$), 0.218 ($p < 0.001$), 0.169 ($p < 0.001$), and 0.097 ($p < 0.001$). Significance remained roughly the same across all four models.

Race appeared to be a largely insignificant factor in male vaccination uptake, with most groups being similar to non-Hispanic whites in their likelihood. In Model 2, when race is first introduced, none of the racial coefficients were significant. This remained the case in Model 3 when education and income were added, but changed slightly in Model 4 when access to healthcare was added. In this final model, being a hispanic male increased the odds of vaccination by 35.1% ($p < 0.05$) when compared to non-Hispanic whites. All other racial groups remained statistically insignificant.

Income was a largely insignificant factor for males, with none of the income groups being significantly different from the < $35,000 group when first controlled for in Model 3. Once access to healthcare was added in Model 4, however, having an income of ≥ $100,000 became significant, decreasing the odds of vaccination uptake by a factor of 0.616 ($p < 0.05$) when compared to those making less than $35,000. All other income groups remained insignificant in the final model.

When education was added as a control variable in Model 3, it showed that both having a high school education and having any college education increased the odds of vaccination uptake when compared to those without a high school education by 62.8% ($p < 0.05$) and 147.8% ($p < 0.001$), respectively. When controls for access to healthcare were added in Model 4, having a high school education lost significance. Having any college education remained significant, however, the coefficient is reduced by roughly half, with having any college education increasing the odds by 76.6% ($p < 0.01$) when compared to those without a high school education.

Insurance status, introduced in Model 4, did not have a significant association with the likelihood of vaccination uptake. Those who had public insurance, private insurance, or a mix of these two saw no difference in their odds when compared to those who had no insurance at all. Having private insurance coverage appears to just fall short of the threshold for statistical significance, however.

Having a usual place of care was a significant factor for males when introduced in Model

4. Those who have a usual place of care saw their odds of vaccination uptake increase by 55.7% ($p < 0.001$) when compared to their peers without a usual place of care. Receipt of the hepatitis B vaccination was also significant and appears to have a large effect on the odds of HPV vaccination, with those who have received the vaccination for hepatitis B seeing their odds increase by a factor of 3.629 ($p < 0.001$) when compared to those who have not received the vaccination.

Table 2. Logistic Regression of Vaccination Uptake on Selected Independent Variables for Male-Only Sample

	Model 1	**Model 2**	**Model 3**	**Model 4**
2010	Reference	Reference	Reference	Reference
2011	1.856*	1.853*	1.860*	1.799*
2012	3.870***	3.862***	3.865***	3.968***
2013	8.610***	8.615***	8.592***	9.483***
2014	9.680***	9.641***	9.605***	10.912***
18	Reference	Reference	Reference	Reference
19	0.448***	0.448***	0.332***	0.391***
20	0.387***	0.386***	0.277***	0.342***
21	0.272***	0.271***	0.192***	0.236***
22	0.225***	0.225***	0.158***	0.188***
23	0.239***	0.238***	0.163***	0.192***
24	0.255***	0.254***	0.181***	0.218***
25	0.187***	0.187***	0.134***	0.169***
26	0.106***	0.107***	0.075***	0.097***
White	---	Reference	Reference	Reference
Black	---	0.876	0.949	1.123
Asian	---	0.910	0.825	0.788
Hispanic	---	0.998	1.120	1.351*
Other	---	0.705	0.827	0.950
< \$35,000	---	---	Reference	Reference
\$35,000 – \$49,999	---	---	0.943	0.938
\$50,000 – \$74,999	---	---	0.770	0.751
\$75,000 – \$99,999	---	---	0.968	0.841
≥ \$100,000	---	---	0.727	0.616*
Less than High School	---	---	Reference	Reference
High School or GED	---	---	1.628**	1.428
Any College	---	---	2.478***	1.766**

Uninsured	---	---	---	Reference
Public	---	---	---	1.411
Private	---	---	---	1.341
Mixed	---	---	---	1.225
Usual Place of Care	---	---	---	1.557***
Delayed Care Due to Cost	---	---	---	0.887
Vaccinated for Hepatitis B	---	---	---	3.629***
Constant	0.037***	0.038***	0.027***	0.007***

** $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$ $N = 8461$*

Coefficients are expressed in terms of odds ratios. Detailed tables available in Appendix A.

Results for female-only logistic regression models are presented in Table 3. Vaccination uptake appears to have increased slightly over time for females, with the odds increasing by a factor of 1.490 ($p < 0.001$), 1.885 ($p < 0.001$), 2.225 ($p < 0.001$), and 2.651 ($p < 0.001$) for the years 2011, 2012, 2013, and 2014, respectively when compared to those in the year 2010 in Model 1. These coefficients stay largely the same when all controls are added in Model 4 with the odds of vaccination uptake for the same set of years increasing by a factor of 1.508 ($p < 0.001$), 1.976 ($p < 0.001$), 2.487 ($p < 0.001$), and 2.799 ($p < 0.001$). Significance levels remained roughly the same across all models.

The odds of HPV vaccination uptake appear to decrease with age for females, however, those in the 19- through 21-year-old age group were not significantly different from their 18-year-old peers in Model 1 when age was first introduced. In this initial model, the odds decrease by a factor of 0.667 ($p < 0.001$), 0.526 ($p < 0.001$), 0.456 ($p < 0.001$), 0.415 ($p < 0.001$), and 0.340 ($p < 0.001$) for 22- through 26-year olds, respectively when compared to 18-year-olds.

In Model 2, once controls for race are added, 21-year-olds became significantly different from 18-year-olds, seeing their odds of vaccination uptake decrease by a factor of 0.807 ($p < 0.05$). 22- through 26-year olds saw their odds of vaccination uptake decrease by a factor of 0.638 ($p < 0.001$), 0.494 ($p < 0.001$), 0.427 ($p < 0.001$), 0.389 ($p < 0.001$), and 0.316 ($p < 0.001$), respectively. When controls for income and education are added in Model 3, all age groups become significantly different from 18-year-olds, with 19- through 26-year olds seeing a decrease in the odds of vaccination uptake by factors of 0.761 ($p < 0.05$), 0.643 ($p < 0.001$), 0.604 ($p < 0.001$), 0.466 ($p < 0.001$), 0.358 ($p < 0.001$), 0.305 ($p < 0.001$), 0.281 ($p < 0.001$), and 0.223 ($p < 0.001$), respectively when compared to 18-year-olds.

Finally, in Model 4 when controls for access to healthcare are added, 19-year-olds lose their significance when compared to 18-year-olds. 20- through 26-year-olds saw their odds of vaccination decrease by a factor of 0.695 ($p < 0.01$), 0.644 ($p < 0.001$), 0.489 ($p < 0.001$), 0.379 ($p < 0.001$), 0.328 ($p < 0.001$), 0.297 ($p < 0.001$), and 0.242 ($p < 0.001$), respectively. While 19- through 21-year-olds see fluctuation in significance across models, those in the 22- through 26-year-old age groups remain significantly less likely to receive the vaccination in all models.

Racial differences in vaccination uptake were significant for females, with non-Hispanic blacks in seeing their odds of vaccination decrease by 38.7% ($p < 0.001$) when compared to their non-Hispanic white counterparts at the first inclusion of race in Model 2. By Model 4, once all controls are added, this gap decreased, with non-Hispanic blacks seeing a decrease in odds of only 24.9% ($p < 0.001$) when compared to non-Hispanic whites.

Non-Hispanic Asians in Model 2 saw a decrease in odds of 46.2% ($p < 0.001$) when compared to their non-Hispanic white counterparts. This coefficient stays largely the same across models, with the non-Hispanic Asians in Model 4 seeing an almost identical decrease in odds of 46.3% ($p < 0.001$). The statistical significance of non-Hispanic Asians stays largely the same across all models.

Hispanics saw the largest difference from non-Hispanic whites in Model 2, with their odds of HPV vaccination uptake decreasing by 53% ($p < 0.001$). This difference shrinks as controls are added, however, with the gap shrinking to 44.6% ($p < 0.001$) in Model 3 and to 35.2% ($p < 0.001$) in Model 4. Being Hispanic remained significantly different from non-Hispanic whites across all models.

Income was a largely insignificant factor for females. At the first introduction of these controls in Model 3, those with incomes greater than or equal to $100,000 saw an their odds of vaccination uptake increase by 22.2% ($p < 0.05$) when compared to their counterparts with incomes less than \$35,000. This difference becomes insignificant in Model 4 once controls for access to healthcare are added. All other income groups were insignificantly different from the reference category of < \$35,000.

Education, when introduced in Model 3, was significant for both those with a high school education and those with any college education when compared to their counterparts with less than a high school education. Those with only a high school education saw their odds of vaccination increase by a factor of 1.312 ($p < 0.01$) when compared to those less than a high school education, while those with any college education seeing their odds increase by a factor of 2.451 ($p < 0.001$). Having only a high school education became insignificantly different from having less than a high school education in Model 4, when controls for access to healthcare are added. Having any college education remained significant, however, with these individuals seeing their odds of vaccination increase by a factor of 1.823 ($p < 0.001$) when compared to their peers with less than a high school education.

Having health insurance of any type significantly increases the odds of HPV vaccination uptake. Females with public insurance saw their odds increase by 20.5% ($p < 0.05$) when compared to those without insurance, while those with private insurance saw their odds increase by 51.3% ($p < 0.001$). Those with a mix of public and private insurance increased their odds of vaccination by 65.6% ($p < 0.05$) when compared to those without insurance.

Having a usual place for receiving healthcare significantly increased the odds of vaccination uptake for females by 43.2% ($p < 0.001$) when compared to those without a usual place of care. Having delayed healthcare in the past year due to cost, however, was an insignificant factor in predicting vaccination uptake. Receipt of the hepatitis B vaccination increased the odds in females by 233.4% ($p < 0.001$) when compared to those who had not received the vaccination.

Table 3. Logistic Regression of Vaccination Uptake on Selected Independent Variables for Female-Only Sample

	Model 1	Model 2	Model 3	Model 4
2010	Reference	Reference	Reference	Reference
2011	1.490^{***}	1.490^{***}	1.492^{***}	1.508^{***}
2012	1.885^{***}	1.890^{***}	1.894^{***}	1.976^{***}
2013	2.225^{***}	2.232^{***}	2.255^{***}	2.487^{***}
2014	2.651^{***}	2.569^{***}	2.516^{***}	2.799^{***}
18	Reference	Reference	Reference	Reference
19	1.020	0.992	0.761^{*}	0.812
20	0.897	0.865	0.643^{***}	0.695^{**}
21	0.850	0.807^{*}	0.604^{***}	0.644^{***}
22	0.667^{***}	0.638^{***}	0.466^{***}	0.489^{***}
23	0.526^{***}	0.494^{***}	0.358^{***}	0.379^{***}
24	0.456^{***}	0.427^{***}	0.305^{***}	0.328^{***}
25	0.415^{***}	0.389^{***}	0.281^{***}	0.297^{***}
26	0.340^{***}	0.316^{***}	0.223^{***}	0.242^{***}
White	---	Reference	Reference	Reference
Black	---	0.613^{***}	0.687^{***}	0.751^{***}
Asian	---	0.538^{***}	0.495^{***}	0.527^{***}
Hispanic	---	0.470^{***}	0.554^{***}	0.648^{***}
Other	---	0.847	0.943	0.996
< $35,000	---	---	Reference	Reference
$35,000 – $49,999	---	---	0.956	0.932
$50,000 – $74,999	---	---	0.976	0.926
$75,000 – $99,999	---	---	1.077	0.995
≥ $100,000	---	---	1.222^{*}	1.088
Less than High School	---	---	Reference	Reference
High School or GED	---	---	1.312^{**}	1.174
Any College	---	---	2.451^{***}	1.823^{***}

Uninsured	---	---	---	Reference
Public	---	---	---	1.205*
Private	---	---	---	1.513***
Mixed	---	---	---	1.656*
Usual Place of Care	---	---	---	1.432***
Delayed Care Due to Cost	---	---	---	0.985
Vaccinated for Hepatitis B	---	---	---	2.334***
Constant	0.435***	0.606***	0.400***	0.146***

* *$p < 0.05$* ** *$p < 0.01$* *** *$p < 0.001$* *$N = 9902$*

Coefficients are expressed in terms of odds ratios. Detailed tables available in Appendix A.

In comparing the male-only regression models presented in Table 2 and the female-only regression models presented in Table 3, we see a couple of distinct differences. Race appears to be a much less significant factor in predicting the likelihood of vaccination uptake among males when compared to females. Almost all race coefficients for females were significant, with the exception of the catch-all “other” category while only Hispanic males were significantly different from their white counterparts. Furthermore, we see that being in any racial group other than non-Hispanic white lowers the odds of vaccination among females while it actually increases the odds among Hispanic males.

While insurance status was an insignificant predictor for males, it was significantly associated with an increase in odds for females. This was true for all types of insurance, with females having a mix of public and private coverage seeing the largest increase in odds (65.6%; $p < 0.05$). However, it is also worth noting that the only female insurance coefficient to attain the highest level of significance (private insurance; $p < 0.001$) was also the coefficient to just barely miss the threshold for statistical significance in the male-only models.

A set of full-sample regression models, available in Appendix B, demonstrate that females remain significantly more likely to vaccinate against HPV than males. This remains the case even as all controls are added. The full-sample results largely mirror those stratified by sex and affirm the findings in prior literature regarding higher uptake among females.

As shown in Figure 1 and Table 4, post-estimation analyses confirmed the findings regarding race that only Hispanic males are more likely than their white counterparts to receive the HPV vaccination.[1] Hispanic males have a predicted probability of about 0.009 higher when all other variables are held at their means. Likewise, as shown in Figure 2 and Table 5 post-

1 All post-estimations are based on the full model for each sex. All variables that do not have their values explicitly specified in these models are held at their mean for purposes of simulation.

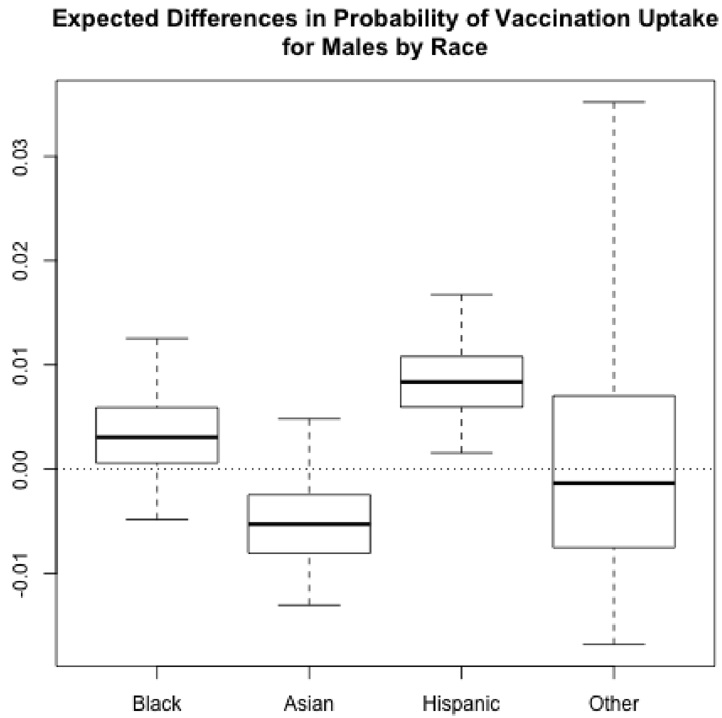
estimation in the female sample reveals that blacks, Asians, and Hispanics are all less likely than whites to vaccinate. Asian females show the largest difference in predicted probability at about 0.126 lower than their white counterparts. Blacks have a predicted probability that is 0.061 lower while Hispanics have a predicted probability of 0.089 lower. Racial variables that were insignificant in the full logistic regression model remained insignificant in post-estimation.

Vaccination among females has been increasing over time and logistic regression models show that Hispanic females are significantly less likely than whites to vaccinate. However, post-estimation in Figure 4 and Table 6 shows that the gap between white and Hispanic females appears to be widening with each year. In 2010, Hispanic females had a predicted probability of vaccination that was 0.064 lower than their white counterparts. In 2011, this increases to 0.081. By 2014, Hispanic females had a predicted probability that was 0.102 lower. We see similar results in the post-estimation for other racial minority groups (results available in Appendix C); however, Hispanic females appear to be the most indicative of this trend.

While Asian females were generally less likely to vaccinate against HPV than whites, post-estimation models in Figure 5 and Table 7 showed that the gap appears to increase with education. Asian females with less than a high school education have a predicted probability of vaccination that is 0.1 lower than their white counterparts. For Asian females with only a high school diploma or GED, this gap increases to 0.11 and to 0.137 for Asian females with any college education. Again, we see that this trend occurs in other racial minority groups (results available in Appendix C); however, Asian females are the most indicative of the effects of education on these groups.

Lastly, in Figures 6 and 7 and Table 8, we see in the post-estimation results that access to healthcare increases the probability of vaccination uptake. Specifically, having a usual place for receiving healthcare is associated with an increase in vaccination uptake for all racial groups. This result remains true for males and females alike. White females appear to benefit most from having a usual place of care, having a predicted probability 0.078 higher than their counterparts without a usual place of care. Asian males appear to benefit the least, with a predicted probability that is only 0.009 higher.

Figure 1



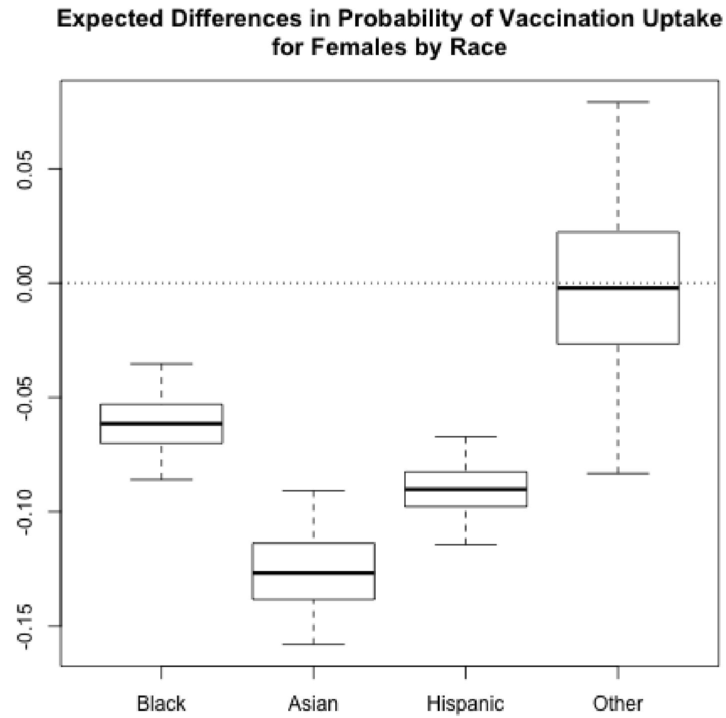
Values are expressed as the difference between the specified race and their white counterparts. All other values are set to their means. Based on a series of 1,000 simulations. Plot extremes represent 95% confidence intervals.

Table 4. Expected Differences in Probability of Vaccination Uptake for Males by Race

	2.50%	Mean	97.50%
White	0.0213	0.026	0.031
Black	0.021	0.029	0.038
Black - White	-0.004	0.003	0.013
Asian	0.014	0.021	0.031
Asian - White	-0.013	-0.005	0.004
Hispanic	0.027	0.034	0.043
Hispanic - White	0.001	0.009	0.018
Other	0.010	0.027	0.061
Other - White	-0.017	0.002	0.034

All other values are set to their means. Based on a series of 1,000 simulations.

Figure 2



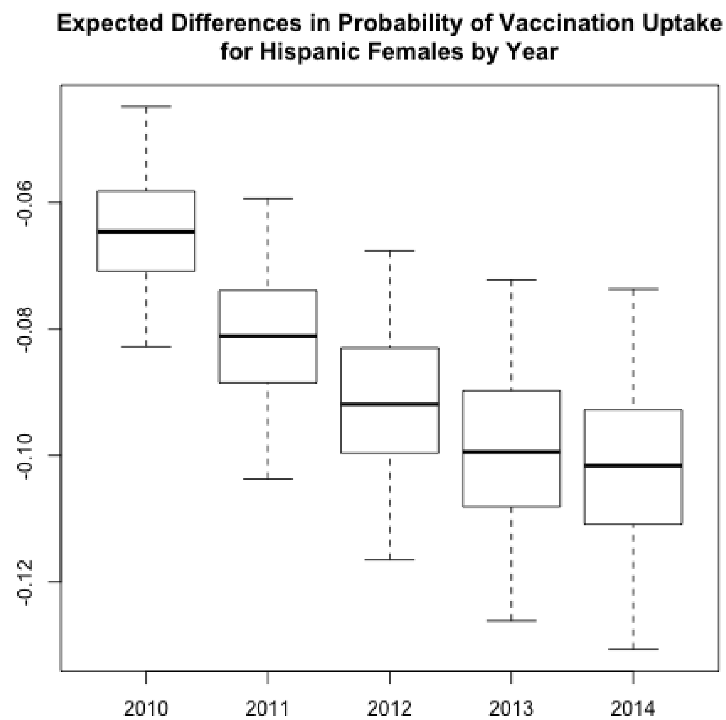
Values are expressed as the difference between the specified race and their white counterparts. All other values are set to their means. Based on a series of 1,000 simulations. Plot extremes represent 95% confidence intervals.

Table 5. Expected Differences in Probability of Vaccination Uptake for Females by Race

	2.50%	Mean	97.50%
White	0.325	0.339	0.354
Black	0.256	0.278	0.301
Black - White	-0.089	-0.061	-0.035
Asian	0.182	0.213	0.246
Asian - White	-0.157	-0.126	-0.091
Hispanic	0.230	0.249	0.269
Hispanic - White	-0.064	-0.089	-0.064
Other	0.324	0.338	0.352
Other - White	0.269	0.339	0.420

All other values are set to their means. Based on a series of 1,000 simulations.

Figure 3



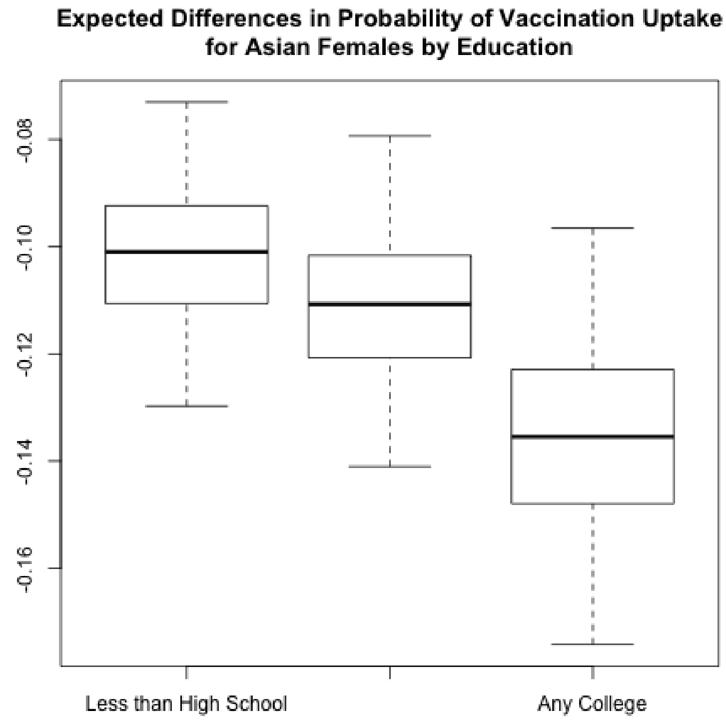
Values are expressed as the difference between Hispanic females and their white counterparts. All other values are set to their means. Based on a series of 1,000 simulations. Plot extremes represent 95% confidence intervals.

Table 6. Expected Differences in Probability of Vaccination Uptake for Hispanic Females by Year

	2.50%	**Mean**	**97.50%**
Hispanic: 2010	0.132	0.151	0.171
White: 2010	0.193	0.215	0.238
Hispanic - White	-0.082	-0.064	-0.046
Hispanic: 2011	0.187	0.212	0.235
White: 2011	0.269	0.293	0.315
Hispanic - White	-0.103	-0.081	-0.058
Hispanic: 2012	0.233	0.260	0.287
White: 2012	0.327	0.352	0.376
Hispanic - White	-0.117	-0.091	-0.065
Hispanic: 2013	0.278	0.307	0.335
White: 2013	0.381	0.406	0.431
Hispanic - White	-0.127	-0.099	-0.070
Hispanic: 2014	0.301	0.332	0.364
White: 2014	0.409	0.434	0.461
Hispanic - White	-0.130	-0.102	-0.076

All other values are set to their means. Based on a series of 1,000 simulations.

Figure 4



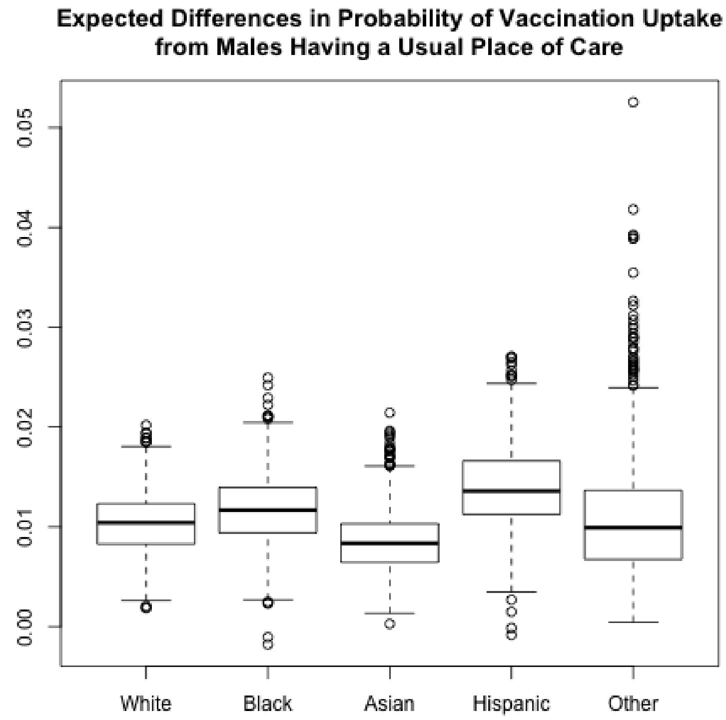
Values are expressed as the difference between Asian females and their white counterparts. All other values are set to their means. Based on a series of 1,000 simulations. Plot extremes represent 95% confidence intervals.

Table 7. Expected Differences in Probability of Vaccination Uptake for Asian Females by Education

	2.50%	**Mean**	**97.50%**
Asian: Less than HS	0.122	0.152	0.187
White: Less than HS	0.222	0.253	0.283
Asian - White	-0.129	-0.100	-0.072
Asian: HS or GED	0.146	0.174	0.206
White: HS or GED	0.263	0.284	0.307
Asian - White	-0.140	-0.110	-0.079
Asian: Any College	0.211	0.245	0.282
White: Any College	0.365	0.382	0.399
Asian - White	-0.175	-0.137	-0.096

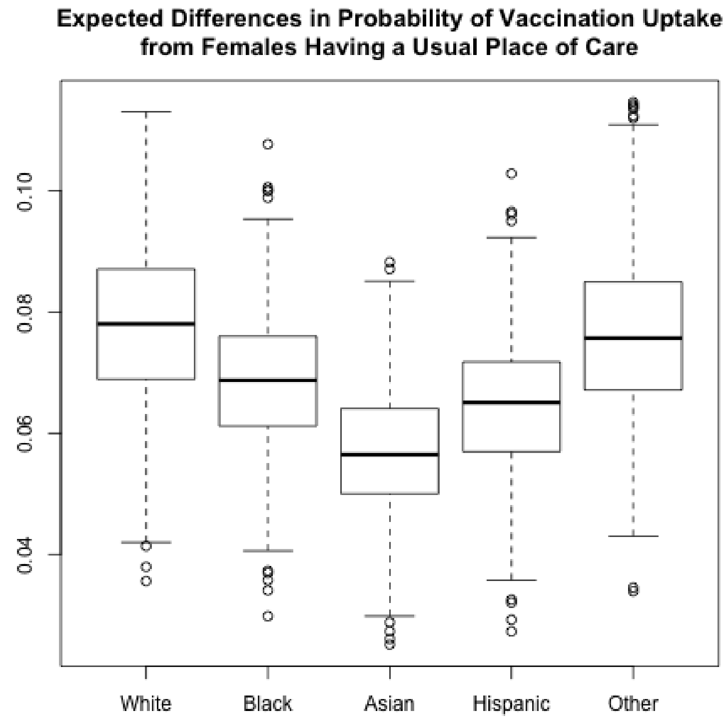
All other values are set to their means. Based on a series of 1,000 simulations.

Figure 5



Values are expressed as the difference between individuals with a usual place of care and their peers without a usual place of care. All other values are set to their means. Based on a series of 1,000 simulations. Plot extremes represent 95% confidence intervals.

Figure 6



Values are expressed as the difference between individuals with a usual place of care and their peers without a usual place of care. All other values are set to their means. Based on a series of 1,000 simulations. Plot extremes represent 95% confidence intervals.

Table 8. Expected Differences in Probability of Vaccination Uptake from Access to Usual Place of Care by Race

	2.50%	Mean	97.50%
Usual: White Males	0.025	0.030	0.036
No Usual: White Males	0.015	0.020	0.024
Usual – No Usual	0.005	0.010	0.016
Usual: Black Males	0.025	0.034	0.045
No Usual: Black Males	0.016	0.022	0.030
Usual – No Usual	0.005	0.012	0.019
Usual: Asian Males	0.016	0.024	0.036
No Usual: Asian Males	0.010	0.016	0.023
Usual – No Usual	0.004	0.009	0.016
Usual: Hispanic Males	0.032	0.040	0.050
No Usual: Hispanic Males	0.019	0.027	0.035
Usual – No Usual	0.006	0.014	0.022
Usual: Other Males	0.011	0.032	0.068
No Usual: Other Males	0.007	0.021	0.048
Usual – No Usual	0.003	0.011	0.026
Usual: White Females	0.342	0.356	0.371
No Usual: White Females	0.255	0.278	0.303
Usual – No Usual	0.053	0.078	0.103
Usual: Black Females	0.270	0.294	0.320
No Usual: Black Females	0.199	0.225	0.252
Usual – No Usual	0.046	0.069	0.090
Usual: Asian Females	0.194	0.227	0.261
No Usual: Asian Females	0.141	0.170	0.200
Usual – No Usual	0.036	0.057	0.078
Usual: Hispanic Females	0.244	0.265	0.286
No Usual: Hispanic Females	0.178	0.201	0.223
Usual – No Usual	0.042	0.064	0.085
Usual: Other Females	0.283	0.358	0.437
No Usual: Other Females	0.216	0.282	0.360
Usual – No Usual	0.050	0.076	0.104

All other values are set to their means. Based on a series of 1,000 simulations.

DISCUSSION

The results presented above yield interesting findings when viewed in light of prior literature and the hypotheses which it guided. The first hypothesis, that non-white females would be less likely to vaccinate than non-Hispanic whites, was largely supported in the findings within the female sample. All major minority racial categories presented held a significantly lower likelihood than their white counterparts, with Asian females being the least likely to vaccinate, followed by Hispanics, and blacks, even once controls for SES and access to healthcare were added.

Furthermore, we also saw that blacks and Hispanics became more likely to vaccinate once income and education were added to the models and saw yet another increase after variables related to access to healthcare are added. As such, this could be the result of these populations, particularly their lower SES groups, being underserved by the healthcare system. They may simply not have the resources and access to services that would lead them to vaccinate against HPV. Once these factors of resources and access are added to the models, we see that these populations begin to move closer to (but still fall short of) the same odds of vaccination as their white counterparts. Such barriers could also play a role in the information deficiencies regarding HPV vaccination that is discussed earlier.

Interestingly, we see that Asian females maintain roughly the same likelihood of vaccination even after income, education, and healthcare access are added to the models. This indicates that, even once this population has access to healthcare services, their vaccination rates remain just as low as before. Such a result could speak to the aforementioned cultural beliefs held by Asians regarding the use of Western medicine or, at the very least, indicates that another factor remains unaccounted for in modeling their likelihood of vaccination, however, this is largely speculation based on the data available in the present study.

The results for males also served to support the hypothesis that males from minority races would be no less likely to vaccinate than their white peers. All major racial categories had largely the same likelihood of vaccination, with the exception of Hispanics being more likely once controlling for healthcare. This appears to offer support for the hypothesis that females are more sensitive to racial disparities than their male counterparts. However, as discussed earlier, this may also simply be due to the fact that racial differences have yet to emerge given the recency of the vaccination's introduction for males.

The evidence presented in the results also does not serve to support the second hypothesis proposed above – that income would have a positive association with vaccination uptake. In both the male and female samples, we see that income remains a largely insignificant predictor. As discussed earlier, the prior literature has failed to reach a consensus regarding whether or not income is a significant predictor of vaccination uptake. It could be the case that the income ranges presented in this analysis were simply not precise enough to highlight differences that occur across income groups or that there simply wasn't enough variation in the incomes of the sample. This could also be a result of individuals in lower income groups being less willing to utilize preventive measures and, instead, waiting to treat an illness once a prognosis has been received.

The third hypothesis – that more highly educated individuals would be more likely to receive the vaccination – was supported by the results. Specifically, the results indicate that having any college education makes an individual more likely to vaccinate against HPV than their peers with less than a high school education. This reinforces prior findings that suggest individuals with a college education have a higher level of awareness than their peers in other education groups.

The evidence presented in the results largely supports the fourth and final hypothesis presented – that access to healthcare would be positively associated with vaccination uptake. As alluded to above, this appears to have been one of the largest factors affecting vaccination uptake, explaining away at least part of the effects from other variables. In the female sample, almost all variables associated with access to healthcare had a significant and positive effect on the odds of vaccination uptake. Having any form of insurance, rather than no insurance, increased the odds of vaccination, as did having a usual place of care and being vaccinated for hepatitis B. These results indicate that having frequent contact with the healthcare system and insurance coverage may, in fact, be one of the most influential factors in females receiving the vaccination for HPV.

Despite the hypothesis that healthcare access would be an insignificant factor for males, the data appear to show that having a usual place of care and being vaccinated for hepatitis B are significantly positive predictors of vaccination uptake among males. Unlike females, insurance status was an insignificant factor for males, potentially due to the HPV vaccination not being pushed as heavily in the preventive aspects of male insurance plans. These results regarding access to healthcare perhaps more generally hint at a changing landscape regarding sexual health in males, as they run counter to the assumption that doctors are more likely to recommend such measures to females.

Many of the results in this study provide evidence to support the fundamental causes theory. In particular, the fact that racial disparities for blacks and Hispanics appear to shrink as controls are added for socioeconomic status and access to healthcare are added suggests these differences may be due to a lack of resources. This lack of resources could be a major factor leading to a lower likelihood of vaccination and, by extension, could elevate the risk factors for cancers associated with HPV later in life.

Nevertheless, male vaccination against HPV remains a relatively new occurrence that cannot be fully understood given current knowledge, limited data, and time constraints. There is still plenty of room for advancement in our understanding of male vaccination in general, as well as the specific factors that lead to gaps in healthcare coverage, cultural differences in uptake rates, and the effects of insurance coverage. Future studies should attempt to further explore the healthcare access issues that affect vaccination uptake in order to gain a better understanding of what barriers exist.

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Appendix A. Comparison of Gender Stratified Regression Models with Confidence Intervals

Table 9. Logistic Regression of Vaccination Uptake on Selected Independent Variables for Male-Only Sample

	Model 1	Model 2	Model 3	Model 4
2010	Reference	Reference	Reference	Reference
2011	1.856*	1.853*	1.860*	1.799*
	(1.058 – 3.392)	(1.056 – 3.386)	(1.059 – 3.403)	(1.021 – 3.300)
2012	3.870***	3.862***	3.865***	3.968***
	(2.317 – 6.835)	(2.312 – 6.820)	(2.311 – 6.833)	(2.364 – 7.040)
2013	8.610***	8.615***	8.592***	9.483***
	(5.328 – 14.852)	(5.331 – 14.862)	(5.309 – 14.840)	(5.833 – 16.440)
2014	9.680***	9.641***	9.605***	10.912***
	(6.012 – 16.654)	(5.987 – 16.589)	(5.955 – 16.549)	(6.725 – 18.891)
18	Reference	Reference	Reference	Reference
19	0.448***	0.448***	0.332***	0.391***
	(0.315 – 0.633)	(0.315 – 0.634)	(0.229 – 0.478)	(0.266 – 0.569)
20	0.387***	0.386***	0.277***	0.342***
	(0.271 – 0.549)	(0.269 – 0.547)	(0.190 – 0.401)	(0.231 – 0.501)
21	0.272***	0.271***	0.192***	0.236***
	(0.184 – 0.395)	(0.184 – 0.394)	(0.127 – 0.284)	(0.154 – 0.355)
22	0.225***	0.225***	0.158***	0.188***
	(0.150 – 0.331)	(0.150 – 0.331)	(0.103 – 0.237)	(0.121 – 0.287)
23	0.239***	0.238***	0.163***	0.192***
	(0.164 – 0.345)	(0.163 – 0.343)	(0.109 – 0.241)	(0.126 – 0.287)
24	0.255***	0.254***	0.181***	0.218***
	(0.175 – 0.367)	(0.174 – 0.365)	(0.121 – 0.265)	(0.144 – 0.326)
25	0.187***	0.187***	0.134***	0.169***
	(0.125 – 0.275)	(0.125 – 0.275)	(0.088 – 0.201)	(0.109 – 0.258)
26	0.106***	0.107***	0.075***	0.097***
	(0.064 – 0.168)	(0.065 – 0.169)	(0.045 – 0.121)	(0.057 – 0.159)

White	---	Reference	Reference	Reference
Black	---	0.876 (0.644 – 1.173)	0.949 (0.696 – 1.275)	1.123 (0.815 – 1.527)
Asian	---	0.910 (0.600 – 1.335)	0.825 (0.543 – 1.214)	0.788 (0.515 – 1.167)
Hispanic	---	0.998 (0.783 – 1.265)	1.120 (0.873 – 1.430)	1.351* (1.040 – 1.748)
Other	---	0.705 (0.245 – 1.598)	0.827 (0.287 – 1.875)	0.950 (0.328 – 2.173)
< $35,000	---	---	Reference	Reference
$35,000 – $49,999	---	---	0.943 (0.696 – 1.261)	0.938 (0.688 – 1.263)
$50,000 – $74,999	---	---	0.770 (0.549 – 1.060)	0.751 (0.531 – 1.042)
$75,000 – $99,999	---	---	0.968 (0.646 – 1.407)	0.841 (0.554 – 1.242)
≥ $100,000	---	---	0.727 (0.501 – 1.029)	0.616* (0.419 – 0.886)
Less than High School	---	---	Reference	Reference
High School or GED	---	---	1.628** (1.146 – 2.347)	1.428 (0.993 – 2.083)
Any College	---	---	2.478*** (1.757 – 3.560)	1.766** (1.219 – 2.598)
Uninsured	---	---	---	Reference
Public	---	---	---	1.411 (0.973 – 2.042)
Private	---	---	---	1.341 (1.000 – 1.816)
Mixed	---	---	---	1.225 (0.267 – 3.985)

Usual Place of Care	---	---	---	1.557***
				(1.212 – 2.016)
Delayed Care Due to Cost	---	---	---	0.887
				(0.618 – 1.246)
Vaccinated for Hepatitis B	---	---	---	3.629***
				(2.898 – 4.574)
Constant	0.037***	0.038***	0.027***	0.007***
	(0.021 – 0.059)	(0.022 – 0.062)	(0.014 – 0.047)	(0.003 – 0.013)

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$ $N = 8461$

Coefficients are expressed in terms of odds ratios. Confidence intervals are in parentheses.

Table 10. Logistic Regression of Vaccination Uptake on Selected Independent Variables for Female-Only Sample

	Model 1	Model 2	Model 3	Model 4
2010	Reference	Reference	Reference	Reference
2011	1.490***	1.490***	1.492***	1.508***
	(1.280 – 1.737)	(1.278 – 1.740)	(1.277 – 1.744)	(1.287 – 1.769)
2012	1.885***	1.890***	1.894***	1.976***
	(1.626 – 2.187)	(1.628 – 2.197)	(1.629 – 2.205)	(1.694 – 2.308)
2013	2.225***	2.232***	2.255***	2.487***
	(1.917 – 2.587)	(1.919 – 2.599)	(1.936 – 2.630)	(2.127 – 2.912)
2014	2.651***	2.569***	2.516***	2.799***
	(2.283 – 3.082)	(2.209 – 2.992)	(2.159 – 2.935)	(2.392 – 3.279)
18	Reference	Reference	Reference	Reference
19	1.020	0.992	0.761*	0.812
	(0.833 – 1.251)	(0.807 – 1.219)	(0.614 – 0.942)	(0.653 – 1.010)
20	0.897	0.865	0.643***	0.695**
	(0.733 – 1.098)	(0.705 – 1.062)	(0.519 – 0.796)	(0.558 – 0.864)
21	0.850	0.807*	0.604***	0.644***
	(0.698 – 1.035)	(0.661 – 0.986)	(0.490 – 0.745)	(0.520 – 0.797)
22	0.667***	0.638***	0.466***	0.489***
	(0.548 – 0.812)	(0.523 – 0.778)	(0.378 – 0.574)	(0.395 – 0.605)
23	0.526***	0.494***	0.358***	0.379***
	(0.432 – 0.641)	(0.404 – 0.604)	(0.290 – 0.441)	(0.306 – 0.470)
24	0.456***	0.427***	0.305***	0.328***
	(0.374 – 0.556)	(0.349 – 0.522)	(0.247 – 0.377)	(0.264 – 0.407)
25	0.415***	0.389***	0.281***	0.297***
	(0.339 – 0.506)	(0.318 – 0.477)	(0.227 – 0.347)	(0.239 – 0.369)
26	0.340***	0.316***	0.223***	0.242***
	(0.278 – 0.416)	(0.257 – 0.388)	(0.180 – 0.276)	(0.194 – 0.302)

White	---	Reference	Reference	Reference
Black	---	0.613*** (0.542 – 0.691)	0.687*** (0.606 – 0.777)	0.751*** (0.660 – 0.854)
Asian	---	0.538*** (0.442 – 0.652)	0.495*** (0.407 – 0.601)	0.527*** (0.431 – 0.642)
Hispanic	---	0.470*** (0.418 – 0.528)	0.554*** (0.491 – 0.624)	0.648*** (0.571 – 0.734)
Other	---	0.847 (0.605 – 1.175)	0.943 (0.670 – 1.316)	0.996 (0.700 – 1.405)
< $35,000	---	---	Reference	Reference
$35,000 – $49,999	---	---	0.956 (0.834 – 1.094)	0.932 (0.810 – 1.071)
$50,000 – $74,999	---	---	0.976 (0.848 – 1.122)	0.926 (0.801 – 1.070)
$75,000 – $99,999	---	---	1.077 (0.892 – 1.298)	0.995 (0.819 – 1.206)
≥ $100,000	---	---	1.222* (1.033 – 1.444)	1.088 (0.913 – 1.295)
Less than High School	---	---	Reference	Reference
High School or GED	---	---	1.312** (1.109 – 1.554)	1.174 (0.988 – 1.399)
Any College	---	---	2.451*** (2.098 – 2.871)	1.823*** (1.544 – 2.158)
Uninsured	---	---	---	Reference
Public	---	---	---	1.205* (1.040 – 1.397)
Private	---	---	---	1.513*** (1.333 – 1.718)
Mixed	---	---	---	1.656* (1.040 – 2.611)

Usual Place of Care	---	---	---	1.432***
				(1.267 – 1.619)
Delayed Care Due to Cost	---	---	---	0.985
				(0.861 – 1.126)
Vaccinated for Hepatitis B	---	---	---	2.334***
				(2.117 – 2.575)
Constant	0.435***	0.606***	0.400***	0.146***
	(0.361 – 0.523)	(0.499 – 0.735)	(0.319 – 0.501)	(0.111 – 0.191)

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$ N = 9902

Coefficients are expressed in terms of odds ratios. Confidence intervals are in parentheses.

Appendix B. Comparison of Full Sample Regression Models

Table 11. Logistic Regression of Vaccination Uptake on Selected Independent Variables for Full Sample

	Model 1	Model 2	Model 3	Model 4
Female	9.651***	9.866***	9.873***	9.492***
	(8.687 – 10.746)	(8.875 – 10.992)	(8.876 – 11.007)	(8.512 – 10.608)
2010	Reference	Reference	Reference	Reference
2011	1.504***	1.502***	1.502***	1.512***
	(1.301 – 1.741)	(1.298 – 1.740)	(1.297 – 1.742)	(1.302 – 1.759)
2012	1.994***	1.995***	1.996***	2.088***
	(1.734 – 2.297)	(1.733 – 2.300)	(1.732 – 2.304)	(1.806 – 2.418)
2013	2.629***	2.635***	2.652***	2.952***
	(2.287 – 3.028)	(2.290 – 3.037)	(2.301 – 3.060)	(2.553 – 3.420)
2014	3.123***	3.039***	2.993***	3.378***
	(2.717 – 3.595)	(2.642 – 3.502)	(2.598 – 3.454)	(2.921 – 3.913)
18	Reference	Reference	Reference	Reference
19	0.815*	0.792*	0.602***	0.650***
	(0.682 – 0.974)	(0.662 – 0.948)	(0.500 – 0.725)	(0.537 – 0.785)
20	0.711***	0.686***	0.503***	0.552***
	(0.596 – 0.849)	(0.574 – 0.820)	(0.417 – 0.606)	(0.456 – 0.667)
21	0.646***	0.615***	0.452***	0.488***
	(0.543 – 0.769)	(0.516 – 0.733)	(0.376 – 0.543)	(0.404 – 0.588)
22	0.514***	0.490***	0.353***	0.375***
	(0.432 – 0.611)	(0.411 – 0.584)	(0.293 – 0.425)	(0.311 – 0.453)
23	0.423***	0.399***	0.284***	0.304***
	(0.355 – 0.504)	(0.334 – 0.476)	(0.235 – 0.342)	(0.251 – 0.368)
24	0.376***	0.354***	0.251***	0.273***
	(0.315 – 0.448)	(0.296 – 0.423)	(0.208 – 0.303)	(0.225 – 0.331)
25	0.333***	0.314***	0.225***	0.242***
	(0.278 – 0.398)	(0.262 – 0.376)	(0.186 – 0.271)	(0.200 – 0.294)
26	0.262***	0.246***	0.172***	0.190***
	(0.218 – 0.314)	(0.205 – 0.296)	(0.142 – 0.209)	(0.156 – 0.231)

White	---	Reference	Reference	Reference
Black	---	0.651*** (0.582 – 0.729)	0.727*** (0.647 – 0.815)	0.799*** (0.708 – 0.901)
Asian	---	0.592*** (0.496 – 0.704)	0.547*** (0.458 – 0.651)	0.576*** (0.480 – 0.688)
Hispanic	---	0.535*** (0.481 – 0.595)	0.628*** (0.563 – 0.700)	0.740*** (0.660 – 0.829)
Other	---	0.815* (0.596 – 1.104)	0.911 (0.663 – 1.239)	0.961 (0.692 – 1.321)
< $35,000	---	---	Reference	Reference
$35,000 – $49,999	---	---	0.963 (0.850 – 1.089)	0.941* (0.828 – 1.069)
$50,000 – $74,999	---	---	0.939* (0.825 – 1.066)	0.896* (0.784 – 1.022)
$75,000 – $99,999	---	---	1.073* (0.905 – 1.269)	0.989 (0.830 – 1.175)
≥ $100,000	---	---	1.106* (0.952 – 1.283)	0.980 (0.839 – 1.144)
Less than High School	---	---	Reference	Reference
High School or GED	---	---	1.369*** (1.175 – 1.599)	1.228* (1.049 – 1.441)
Any College	---	---	2.485*** (2.153 – 2.875)	1.840*** (1.580 – 2.149)
Uninsured	---	---	---	Reference
Public	---	---	---	1.236** (1.077 – 1.419)
Private	---	---	---	1.485*** (1.322 – 1.670)
Mixed	---	---	---	1.685* (1.086 – 2.582)

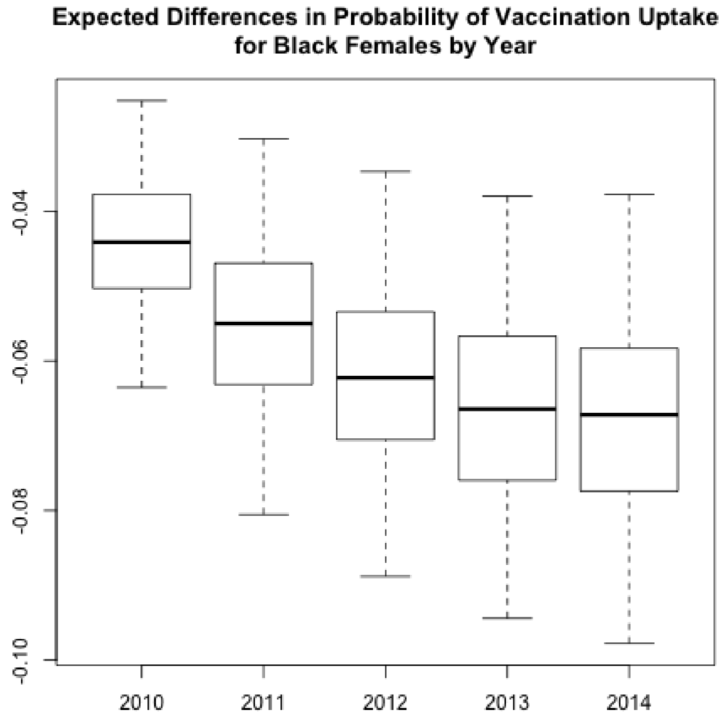
Usual Place of Care	---	---	---	1.450***
				(1.300 – 1.620)
Delayed Care Due to Cost	---	---	---	0.973
				(0.858 – 1.103)
Vaccinated for Hepatitis B	---	---	---	2.531***
				(2.314 – 2.769)
Constant	0.051***	0.067***	0.045***	0.016***
	(0.043 – 0.062)	(0.055 – 0.081)	(0.036 – 0.055)	(0.012 – 0.020)

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$ *N = 18363*

Coefficients are expressed in terms of odds ratios. Confidence intervals are in parentheses.

Appendix C. Additional Postestimation of Predicted Probabilities

Figure 7



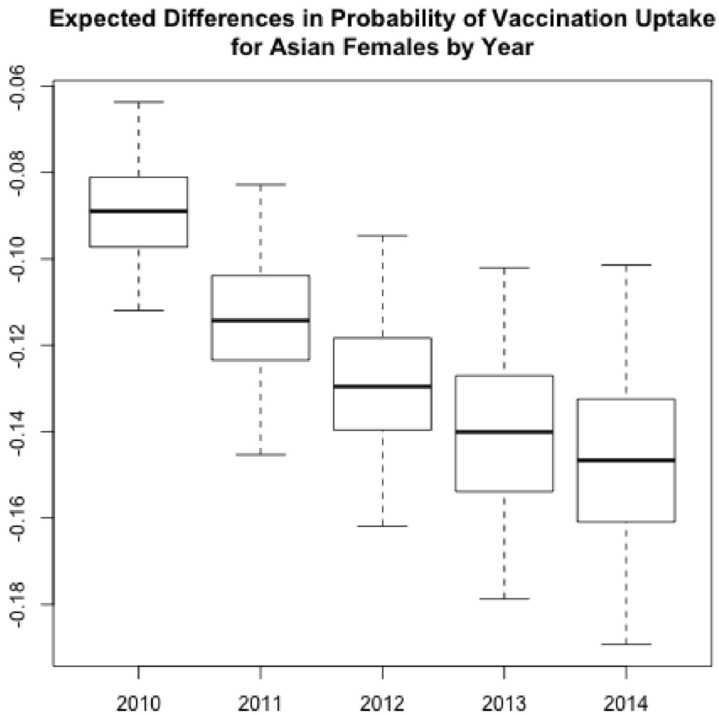
Values are expressed as the difference between black females and their white counterparts. All other values are set to their means. Based on a series of 1,000 simulations. Plot extremes represent 95% confidence intervals.

Table 12. Expected Differences in Probability of Vaccination Uptake for Black Females by Year

	2.50%	**Mean**	**97.50%**
Black: 2010	0.150	0.171	0.194
White: 2010	0.194	0.215	0.238
Black - White	-0.064	-0.044	-0.025
Black: 2011	0.211	0.238	0.264
White: 2011	0.270	0.293	0.317
Black - White	-0.081	-0.055	-0.030
Black: 2012	0.262	0.289	0.319
White: 2012	0.328	0.351	0.374
Black - White	-0.089	-0.062	-0.035
Black: 2013	0.310	0.340	0.370
White: 2013	0.380	0.406	0.433
Black - White	-0.094	-0.066	-0.038
Black: 2014	0.334	0.367	0.400
White: 2014	0.410	0.435	0.460
Black - White	-0.098	-0.068	-0.038

All other values are set to their means. Based on a series of 1,000 simulations.

Figure 8



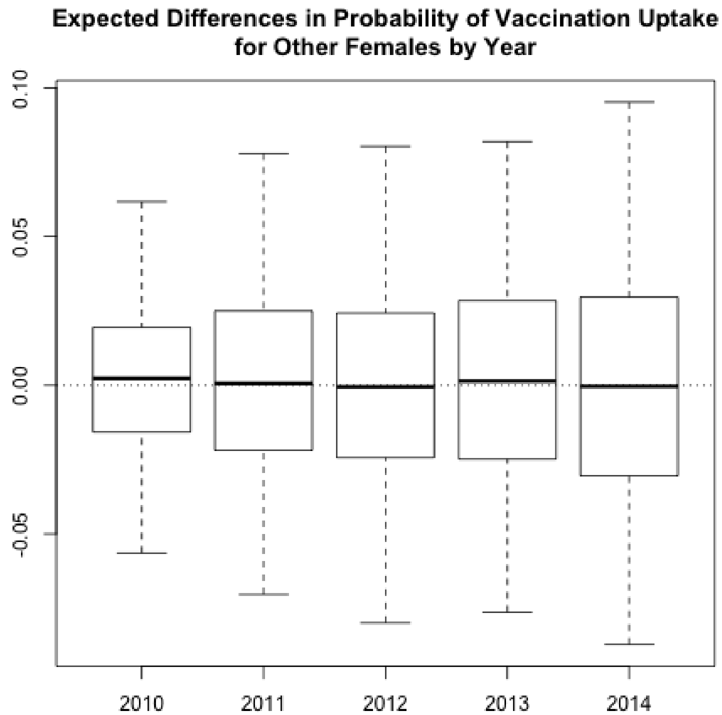
Values are expressed as the difference between Asian females and their white counterparts. All other values are set to their means. Based on a series of 1,000 simulations. Plot extremes represent 95% confidence intervals.

Table 13. Expected Differences in Probability of Vaccination Uptake for Asian Females by Year

	2.50%	Mean	97.50%
Asian: 2010	0.105	0.127	0.154
White: 2010	0.194	0.216	0.239
Asian - White	-0.112	-0.089	-0.064
Asian: 2011	0.149	0.179	0.210
White: 2011	0.269	0.293	0.317
Asian - White	-0.145	-0.114	-0.083
Asian: 2012	0.189	0.223	0.260
White: 2012	0.330	0.352	0.377
Asian - White	-0.162	-0.129	-0.095
Asian: 2013	0.226	0.265	0.309
White: 2013	0.380	0.406	0.432
Asian - White	-0.179	-0.141	-0.102
Asian: 2014	0.247	0.288	0.335
White: 2014	0.409	0.435	0.460
Asian - White	-0.189	-0.147	-0.101

All other values are set to their means. Based on a series of 1,000 simulations.

Figure 9



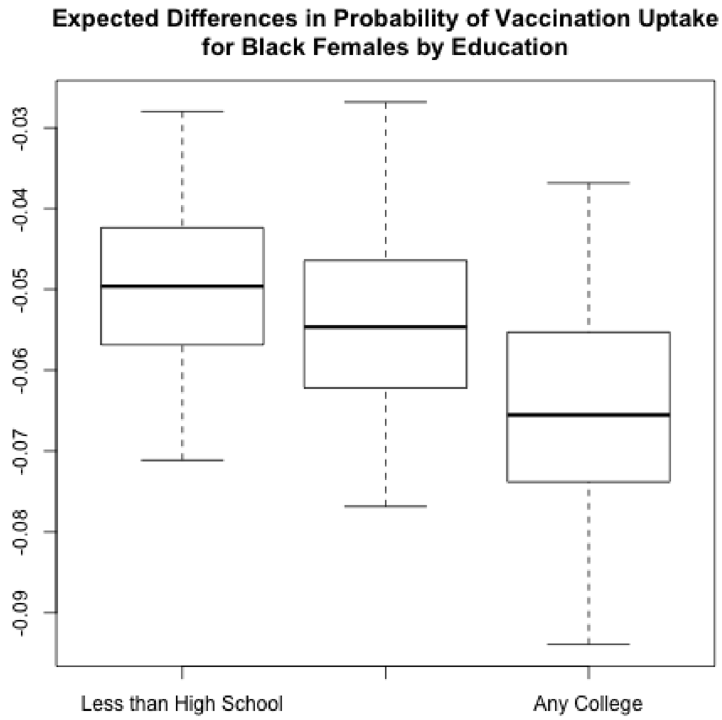
Values are expressed as the difference between other females and their white counterparts. All other values are set to their means. Based on a series of 1,000 simulations. Plot extremes represent 95% confidence intervals.

Table 14. Expected Differences in Probability of Vaccination Uptake for Other Females by Year

	2.50%	**Mean**	**97.50%**
Other: 2010	0.158	0.216	0.281
White: 2010	0.195	0.215	0.238
Other - White	-0.056	0.002	0.062
Other: 2011	0.225	0.295	0.374
White: 2011	0.271	0.293	0.317
Other - White	-0.070	0.002	0.078
Other: 2012	0.272	0.353	0.436
White: 2012	0.329	0.352	0.375
Other - White	-0.080	0.001	0.080
Other: 2013	0.330	0.408	0.489
White: 2013	0.380	0.406	0.429
Other - White	-0.076	0.002	0.082
Other: 2014	0.348	0.435	0.526
White: 2014	0.408	0.435	0.460
Other - White	-0.087	0.001	0.095

All other values are set to their means. Based on a series of 1,000 simulations.

Figure 10



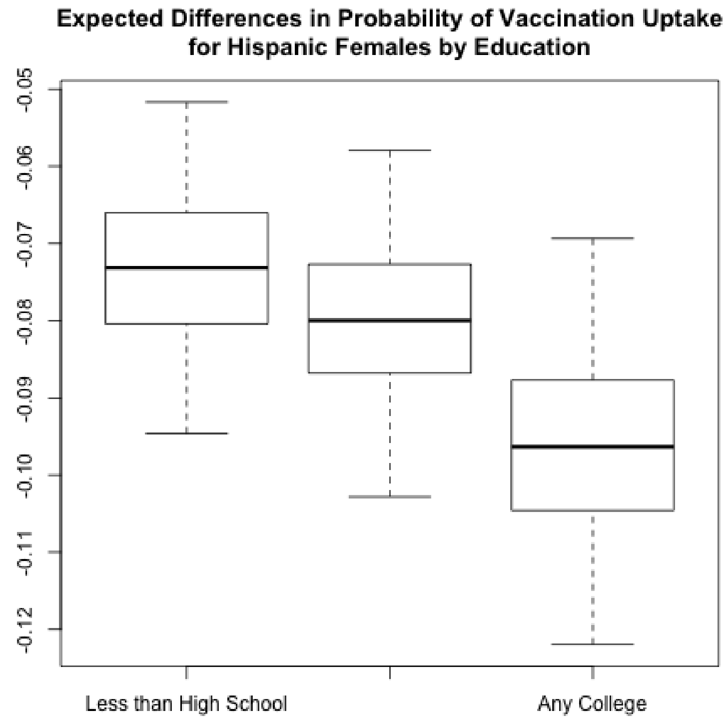
Values are expressed as the difference between black females and their white counterparts. All other values are set to their means. Based on a series of 1,000 simulations. Plot extremes represent 95% confidence intervals.

Table 15. Expected Differences in Probability of Vaccination Uptake for Black Females by Education

	2.50%	Mean	97.50%
Black: Less than HS	0.176	0.204	0.236
White: Less than HS	0.224	0.254	0.285
Black - White	-0.071	-0.050	-0.028
Black: HS or GED	0.206	0.231	0.256
White: HS or GED	0.263	0.285	0.307
Black - White	-0.077	-0.054	-0.027
Black: Any College	0.292	0.317	0.343
White: Any College	0.364	0.382	0.399
Black - White	-0.094	-0.065	-0.037

All other values are set to their means. Based on a series of 1,000 simulations.

Figure 11



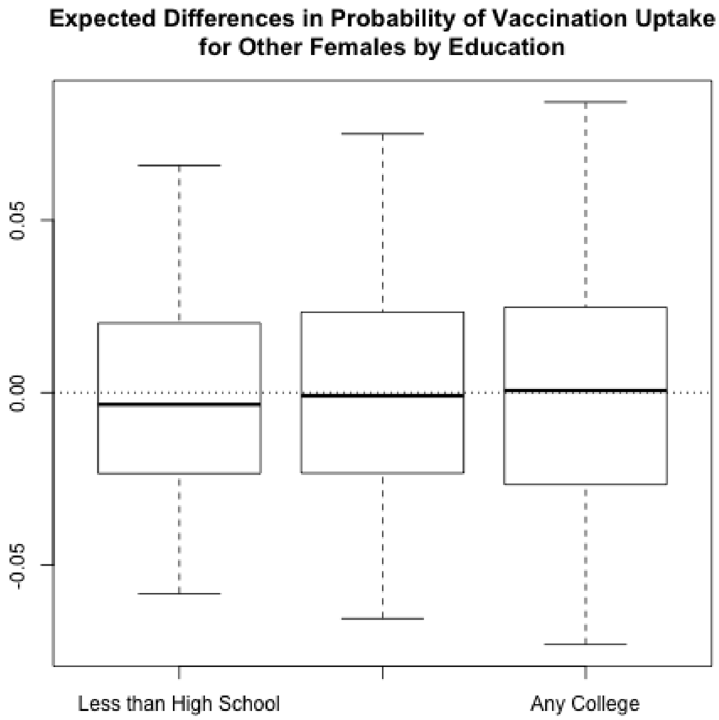
Values are expressed as the difference between Hispanic females and their white counterparts. All other values are set to their means. Based on a series of 1,000 simulations. Plot extremes represent 95% confidence intervals.

Table 16. Expected Differences in Probability of Vaccination Uptake for Hispanic Females by Education

	2.50%	Mean	97.50%
Hispanic: Less than HS	0.157	0.181	0.210
White: Less than HS	0.225	0.254	0.284
Hispanic - White	-0.095	-0.073	-0.052
Hispanic: HS or GED	0.183	0.205	0.229
White: HS or GED	0.265	0.284	0.307
Hispanic - White	-0.103	-0.080	-0.058
Hispanic: Any College	0.262	0.285	0.309
White: Any College	0.365	0.381	0.399
Hispanic - White	-0.122	-0.096	-0.069

All other values are set to their means. Based on a series of 1,000 simulations.

Figure 12



Values are expressed as the difference between other females and their white counterparts. All other values are set to their means. Based on a series of 1,000 simulations. Plot extremes represent 95% confidence intervals.

Table 17. Expected Differences in Probability of Vaccination Uptake for Other Females by Education

	2.50%	Mean	97.50%
Other: Less than HS	0.191	0.253	0.323
White: Less than HS	0.224	0.254	0.285
Other - White	-0.058	-0.001	0.066
Other: HS or GED	0.223	0.286	0.361
White: HS or GED	0.264	0.285	0.307
Other - White	-0.065	0.001	0.075
Other: Any College	0.308	0.382	0.462
White: Any College	0.366	0.382	0.398
Other - White	-0.073	0.000	0.084

All other values are set to their means. Based on a series of 1,000 simulations.